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Dredging Operations Technical Support
Attn: Dr. Engler (601) 634-3624
3909 Halls Ferry Road
Vicksburg, MS 39180-6133

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Dredging Research Technical Notes



An Inexpensive Method for Vibracoring Sands and Fine-Grained Sediments in Shallow Water

Purpose

This technical note summarizes a coring methodology used in support of a Water Injection Dredging (WID) demonstration on the Upper Mississippi River in July 1992. The WID demonstration was sponsored by the Dredging Research Program (DRP) and was a joint effort involving the U.S. Army Engineer Waterways Experiment Station (WES), the U.S. Army Engineer Districts, St. Paul and Rock Island, and Gulf Coast Trailing Company.

This note describes equipment, operational procedures, and capabilities of a vibrating coring system to collect subsurface sediments. The vibracoring system was developed by the WES Coastal Engineering Research Center. The method used is a refinement of a coring system developed previously by Finkelstein and Prins (1981). Information provided should assist in selecting inexpensive equipment and appropriate guidelines for shallow-water coring applications.

Background

Coring of sediments in shallow water with conventional cylindrical coring methods such as the gravity, piston, and Shelby (rod) device have several limitations. Gravity and piston corers often have limited penetration in sand (2 ft or less); conventional drilling equipment used with Shelby tubes can be very expensive. Vibracorers have been used to obtain cores of cohesive and fine-grained sediment on land and in shallow water for over three decades with success.

Improvements in the vibracoring process in shallow-water environments to obtain unconsolidated sands and fine-grained material are described here. Specifically, this technical note describes equipment and methods for inexpensively obtaining cores up to 6 ft long in sands (and probably longer cores in silt) in water depths up to 12 ft and in currents up to 2 ft/sec. The 6-ft depth of penetration makes this method suitable for collecting sediment samples for many maintenance dredging projects and

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some smaller new work dredging projects. For the WID demonstration effort, a minimum core length of 4.0 ft was required, and funds were limited.

Additional Information

For additional information, contact the authors, Mr. J. Bailey Smith, (601) 634-3043, and Mr. James E. Clausner, (601) 634-2009, or the manager of the Dredging Research Program, Mr. E. Clark McNair, Jr., (601) 634-2070.

Test Location

The vibracoring portion of the WID demonstration was conducted during the period July 10-30, 1992, at mile 744.2 of the Mississippi River at the Lower Zumbro site, a channel crossing near Minneiska, Minnesota, approximately 5 miles north of Lock and Dam 5 (approximately 100 miles south of Minneapolis/St. Paul). The availability of support equipment located nearby at the Fountain City, Wisconsin, Service Base of the U.S. Army Engineer District, St. Paul, made this task much easier. The cores were taken in water depths of 9 to 11 ft in currents of about 1.5 ft/sec. There was no wave activity with the exception of occasional boat wakes.

Description of Vibracore Equipment

Thirty-foot sections of 3-in. aluminum irrigation pipe (1/16-in. wall thickness) are recommended for vibracoring applications in unconsolidated sands in shallow water. An overhead structure similar to an A-frame is also required. Equipment necessary for obtaining vibracores includes a 5-hp, four-cycle gasoline engine power source (approximate weight 50 lb) (Figure 1). This power source is modified so that a 13-ft extendable concrete vibrator cable and vibrator head can be attached. A plate and U-bolts are welded to the vibrator head so that the core tube can be secured to the vibrator head assembly. A metal plug is placed inside the core where the vibrator head is attached to prevent crushing the core barrel. The power source, vibrator cable, and vibrator can be purchased for less than \$1,000.

Additional items necessary for the coring operation include a bilge pump rated at 1 gal/min with approximately 35 ft of appropriate flexible tubing, an 8-ft-long chain, tape measure with weight (Figure 1), core caps, vacuum sealer plug, sample retainer (core catcher) made of flexible galvanized tin flashing (Figure 2), and various tools and supplies including a hack saw, wrenches, nuts and bolts, and duct tape.

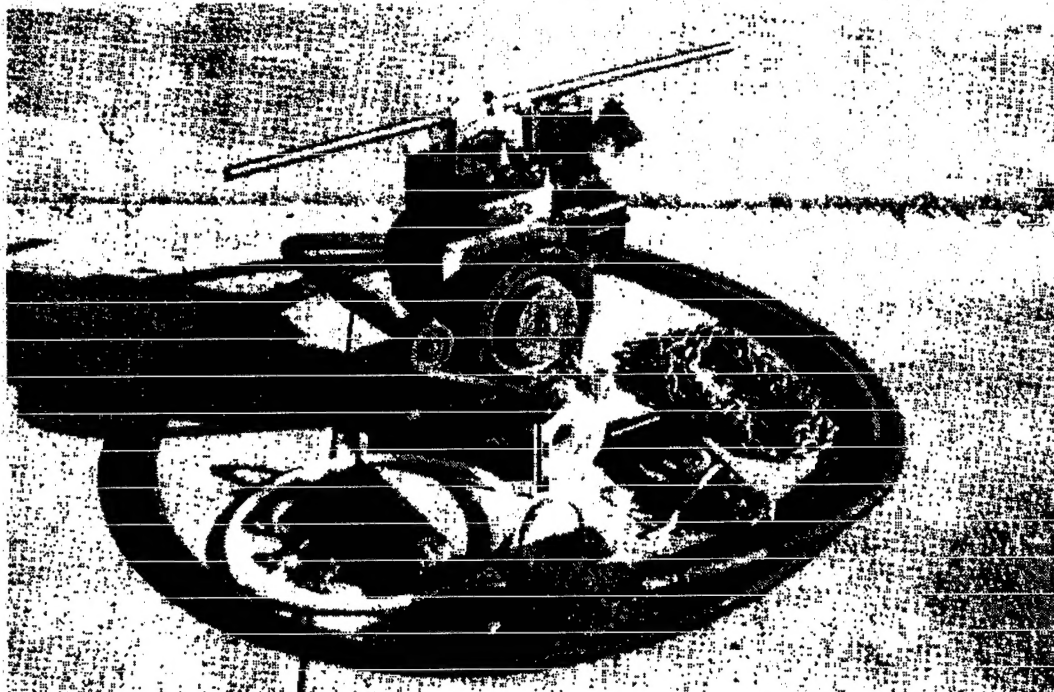


Figure 1. Vibracore equipment, including 5-hp gasoline engine power source, 13-ft vibrator cable, chain, weighted tape measure, duct tape, metal plug, and flexible tubing (scale, at photo center, in inches)

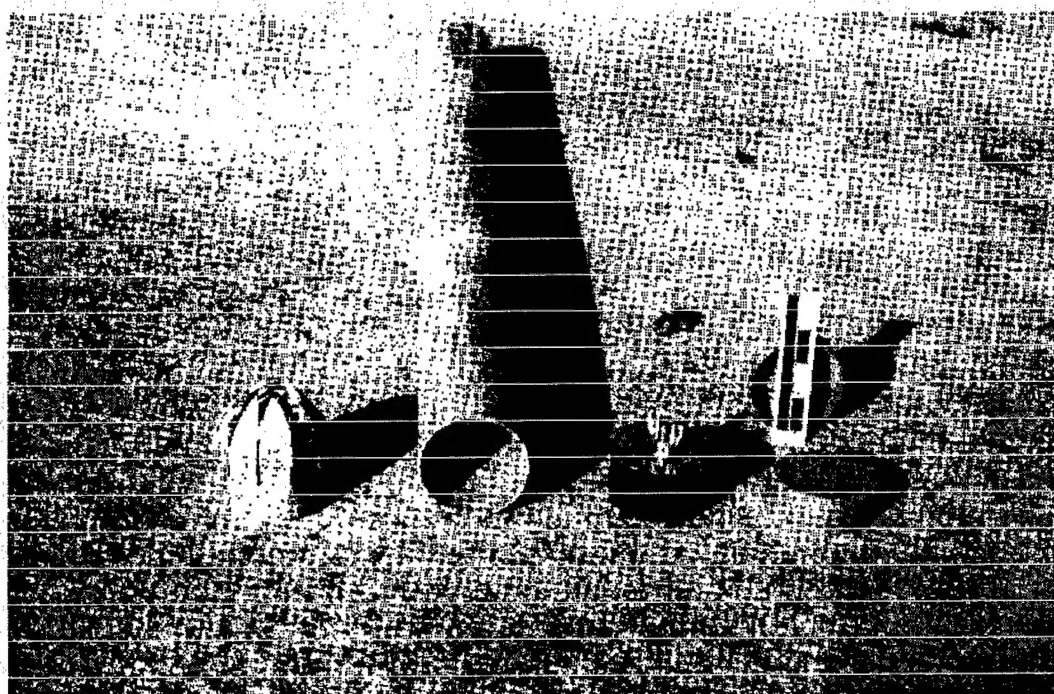


Figure 2. Aluminum core tube with galvanized tin sample retainer, vacuum sealer plug, and plastic core caps (scale in inches)

Vibracore Operation

Seven cores (four predredging and three postdredging) were taken from the dredge tender *Bellevue* (Figure 3) at the Lower Zumbro site in 10 to 11 ft of water (Table 1). The average and maximum core lengths were 4.5 and 5.6 ft, which met the coring depth requirements of 4.0 ft. Modifications to the coring procedure were made throughout the field investigation to obtain maximum core penetration.

Table 1			
Cores Taken at Lower Zumbro Site			
Core No. (Date)	Location, Water Injection State Plane	Water Depth, ft	Core Length, ft
Predredging			
1 (7/10/92)	2554752 E 452080 N	10.5	3.0
2 (7/11/92)	2554593 E 452402 N	10.4	5.0
3 (7/11/92)	2554724 E 452066 N	10.9	4.6
4 (7/13/92)	2554632 E 452182 N	11.0	4.0
Postdredging			
5 (7/30/92)	2554711 E 452084 N	10.5	4.0
6 (7/30/92)	2554622 E 452199 N	10.6	5.0
7 (7/30/92)	2554598 E 452445 N	10.5	5.6

The procedure calls for selection of a core site, after which the vessel must be secured with a three-point mooring (minimum) to prevent swinging due to waves, winds, or wakes from passing vessels. The vibracore process involves first determining the water depth and the length of the core desired. The 30-ft-long core tube can then be cut with a hack saw to the desired length (dependent upon water depth and estimated core length, plus an additional 2 ft). Next, the vibrator head is secured to the core tube at one end using the U-bolts and the metal plug. The sample retainer should be fastened at the other end of the core (this can be done at the dock if desired). The sample retainer is positioned with the crown,



Figure 3. Dredge tender *Bellevue* with A-frame

or fingers, up into the core to enable sediment to enter, but not escape from, the bottom of the core barrel.

Once the core barrel has been prepared, it is lifted and placed in a vertical position resting on the sediment floor underneath an A-frame or similar structure (Figures 4 and 5). The engine is started, and the speed is adjusted to the optimum vibration frequency. The vibrations plus the weight of the vibrator head (supplemented by pushing or standing on the core) penetrate the core into the bottom at different rates depending on sediment characteristics. The unit time of penetration ranges from an average of 5 to 30 sec/ft and decreases as the core penetrates to greater depths.

After maximum penetration of the core is achieved, the engine is stopped and the vibrator head and plug are removed. The length of the core is then measured by sliding the weighted tape measure down the core tube. Next, the core is emptied of water with flexible tubing extending from the bilge pump to the bottom of the inside of the core (making sure not to remove any sediment). This reduces the excess weight of water in the core tube, thus minimizing sediment loss from the bottom of the core. The core is then capped with a vacuum sealer plug to create a vacuum inside the core, which also prevents sediment loss. Extraction of the core requires wrapping the core tube with an overlapped chain and attaching the chain to a cable connected to a winch (Figure 5). The winch should be capable of lifting 1,500 to 2,000 lb.

During extraction, the core is kept as vertical as possible until it is capped on deck. Extracting and capping the core in a timely manner will

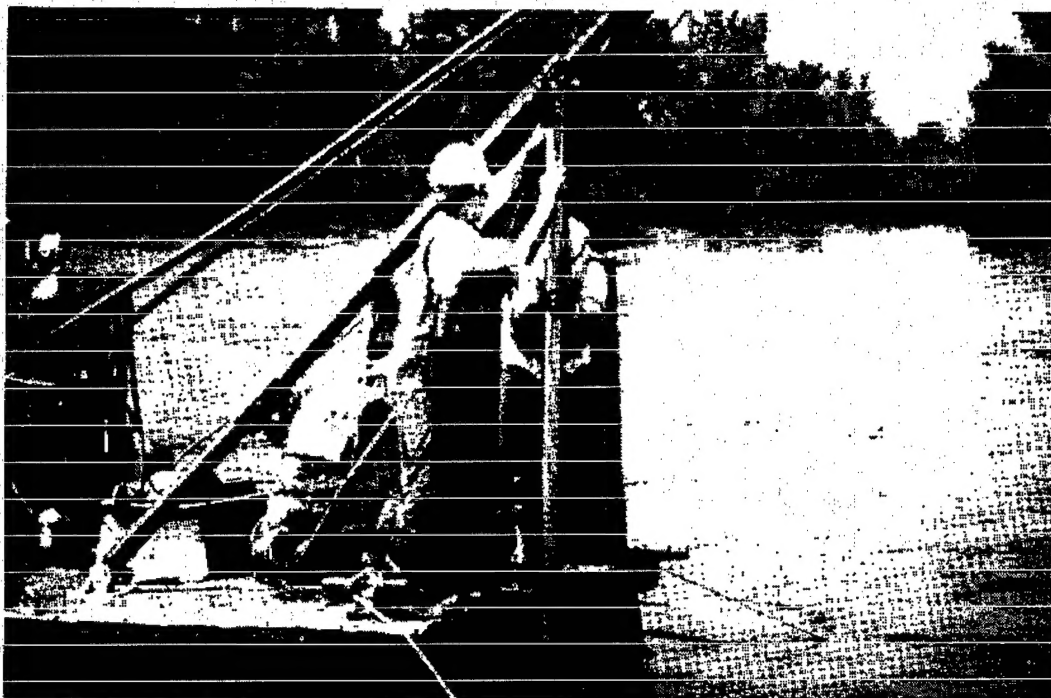


Figure 4. A-frame used during vibracore process

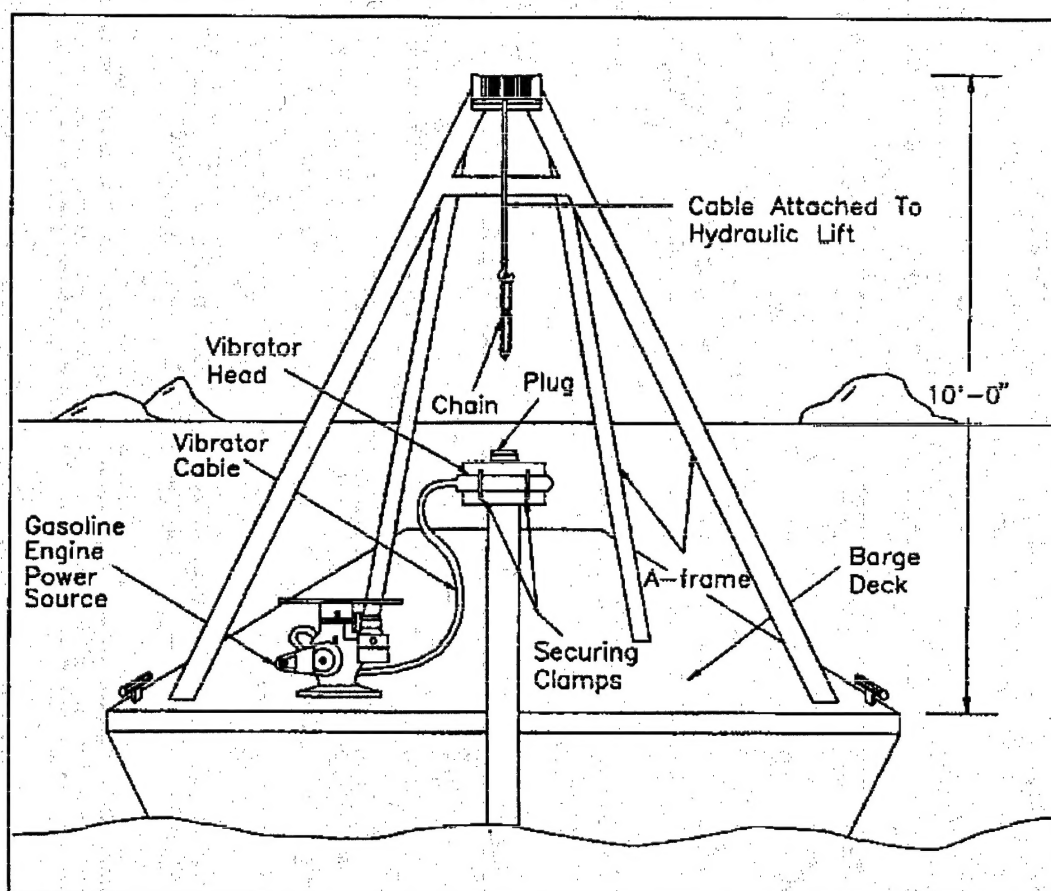


Figure 5. Schematic of dredge tender A-frame and vibracore components

prevent sediment loss. After the lower end of the core is capped, the vacuum plug is removed and the distance to the sediment is again measured to determine if any sediment was lost during extraction. The excess core tube is then cut.

After sealing both ends of the core with caps (Figure 2) and securing each cap with duct tape, the extracted core should be cut into sections of appropriate length for shipping, and labeled according to core number, section, date, and direction (according to both vertical and compass). Archived cores should be treated with care so that sediment bedding will not be disturbed.

The total time necessary for obtaining a single vibracore is approximately 45 min to 1 hr.

Sediment compaction inside the core, or "rodding," during the coring process is determined by comparing the depth of the core barrel penetration (elevation of the top of the core barrel before and after penetration) with the length of core recovered.

Laboratory Analyses

The type of laboratory analysis of the sample is a function of the purpose of core collection. The samples can be removed by extrusion, then placed in plastic bags (for grain size analysis) or glass jars (for chemical analysis). More traditional laboratory analysis of archived cores involves longitudinally splitting the core into halves, photographing the core upon opening (Figure 6), and recording sediment characteristics on a core log sheet. One half of the core is placed and sealed in polyurethane bags for storing purposes, while the other half is sampled for grain-size analysis.

Problems and Solutions

The vibracoring procedures described above were finalized after much trial and error. The ultimate decisions to use the flexible galvanized tin sample retainer and to pump the water prior to extraction of the core were the two most important developments in obtaining a core of sandy, unconsolidated sediments in shallow-water environments. Variations on the method include land-based operations, as outlined by Finkelstein and Prins (1981). For coring in more cohesive sediments, use of the sediment sample retainer is not recommended.

To date, the maximum final core length obtained with this method is 5.6 ft, which is a function of the water depth and height of the A-frame. Therefore, the authors estimate the maximum practical penetration depths of this coring method to be about 10 to 12 ft. Using this method in currents greater than 2 ft/sec is not practical unless the water depth is very shallow (less than 6 ft). In addition, any consistent waves over 0.5 to

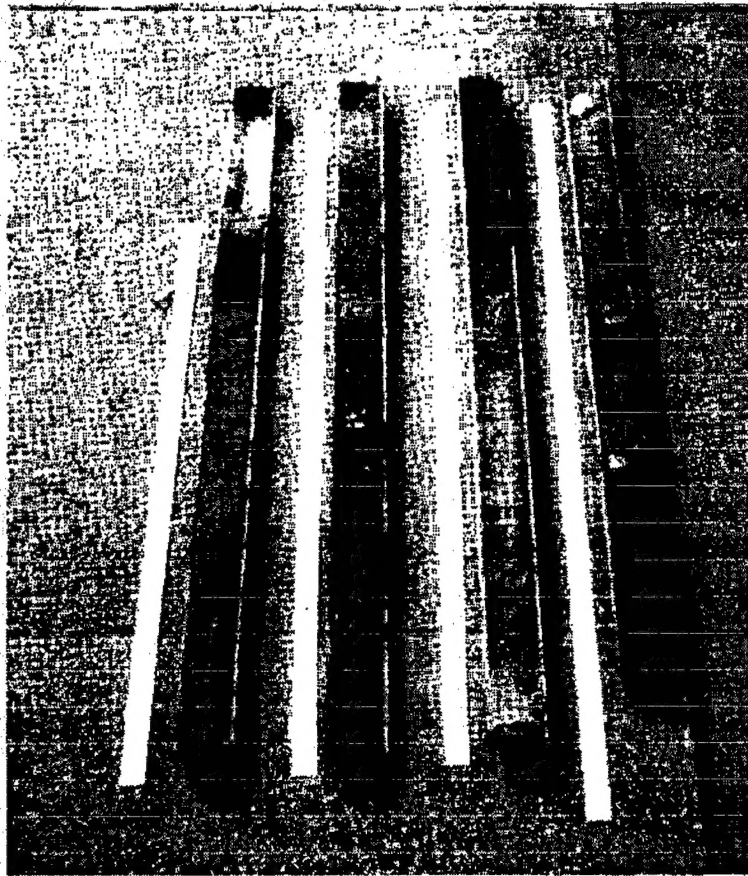


Figure 6. Longitudinally cut core section. (White strips for measurement purposes)

1.0 ft in height would make this method impractical. A taller A-frame with an attached platform (to allow a person to support the upper end of the core tube during extraction) should enable this coring method to be used in water depths up to 15 ft.

Acknowledgments

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Reference

Finkelstein, K., and Prins, D. 1981. "An Inexpensive, Portable Vibracoring System for Shallow-Water and Land Application," Coastal Engineering Technical Aid 81-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.